
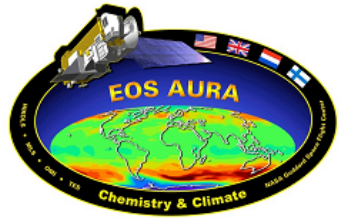


# Comparison of HIRDLS with COSMIC radio occultation temperature profiles.

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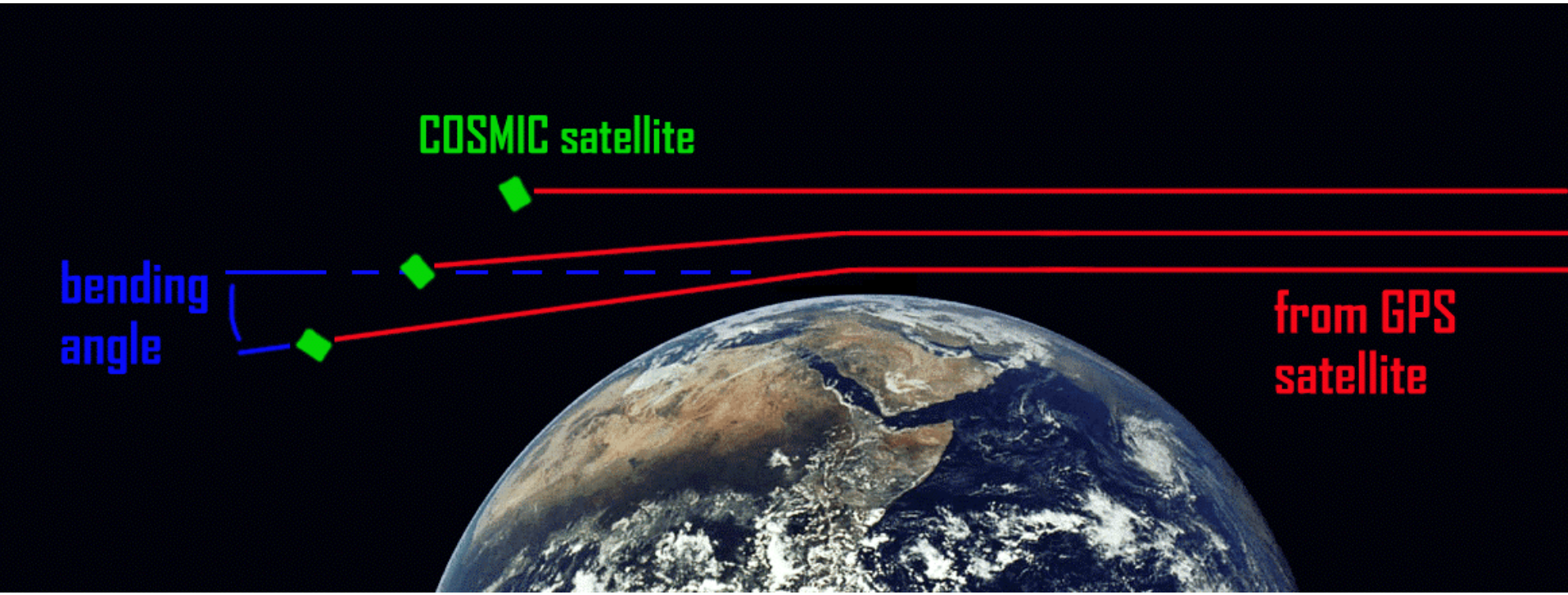
Aura Science Team Meeting, October 2007, Pasadena.

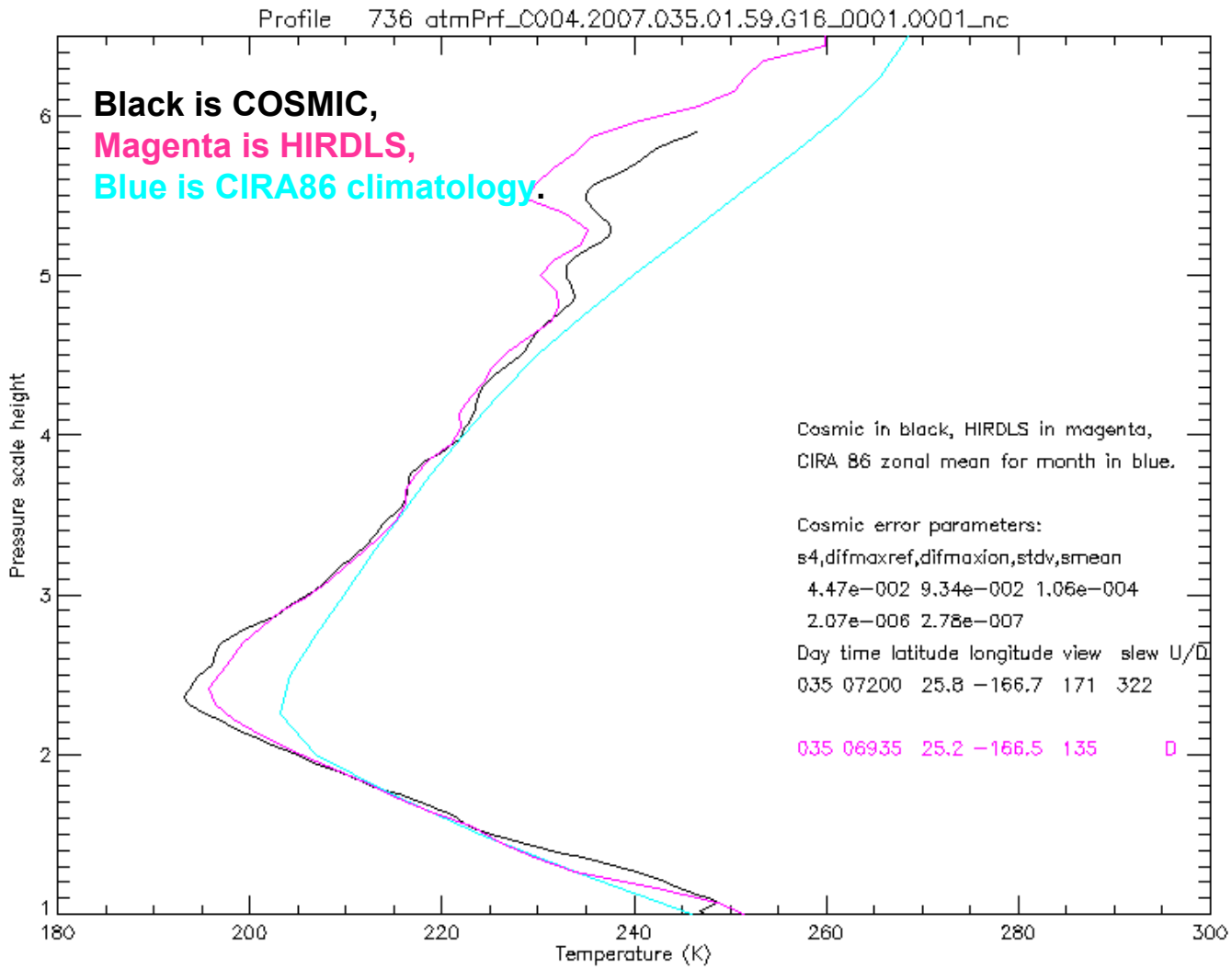
# COSMIC Radio-occultation Measurements




FORMOSAT-3/COSMIC uses 6 low orbit satellites carrying GPS receivers which measure the phase change of GPS signals as the transmission path is occulted by the Earth's limb. This enables the refractivity, hence a combination of temperature and water vapour to be extracted.

Water vapour amounts are so low in the stratosphere that the system gives an accurate temperature measurement.

See: *www.cosmic.ucar.edu*




## Typical HIRDLS comparison with COSMIC GPS radio occultation profile.

Pressure scale height used as vertical scale here $=\log_e(1013/\text{pressure})$

1 scale height = approx 7km

Very tight coincidence requirements still gave sufficient matches over the period 192/2006-239/2007. The two profiles are 265 seconds and about 70 km apart.

Standard publicly available retrievals from the web site were used for this work.

# Value of radio occultation data for HIRDLS validation

GPS radio occultation provides potentially excellent means to validate HIRDLS temperature in the low and middle stratosphere – expected to be good up to 30-35 km.

Totally independent method using different physics.

Vertical resolution should approximately 1 km in the stratosphere, i.e. slightly better than HIRDLS

1000-3000 profiles per day total for the 6 COSMIC satellites.

Profile locations quasi-random although some correlation between the different satellites in the first few months until the satellites orbits shifted (were launched on same satellite). This provides many near-coincidences with HIRDLS profile locations.

Temperature is provided on a pressure scale (as well as height) which is fundamental to HIRDLS.

Quality diagnostics are provided, e.g. fitted bending angle errors.

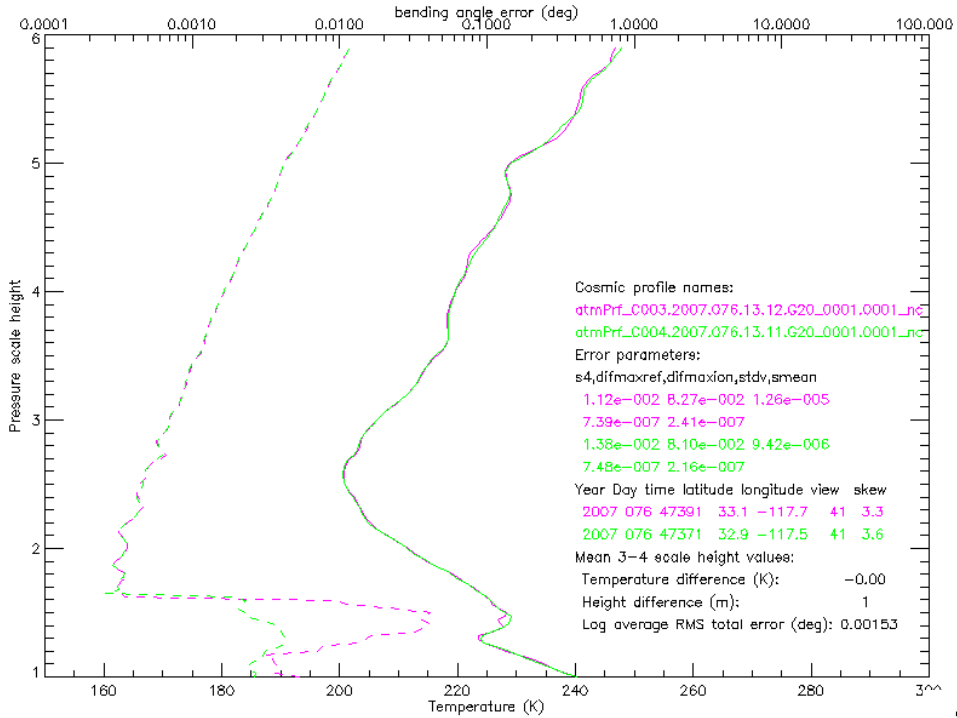
# HIRDLS Data Used

Data for Days 192 2006 to 239 2007 were used.

HIRDLS version 2.04.08 was used, except for August 2007 when version 2.04.09 was used.

Only downward scanning profiles were used because a minor problem had been found affecting upward profiles in version 2.04.08.

The August 2007 version 2.04.09 data should be exactly equivalent to 2.04.08 since downward profiles were unchanged between the versions (just downward scans were still used).



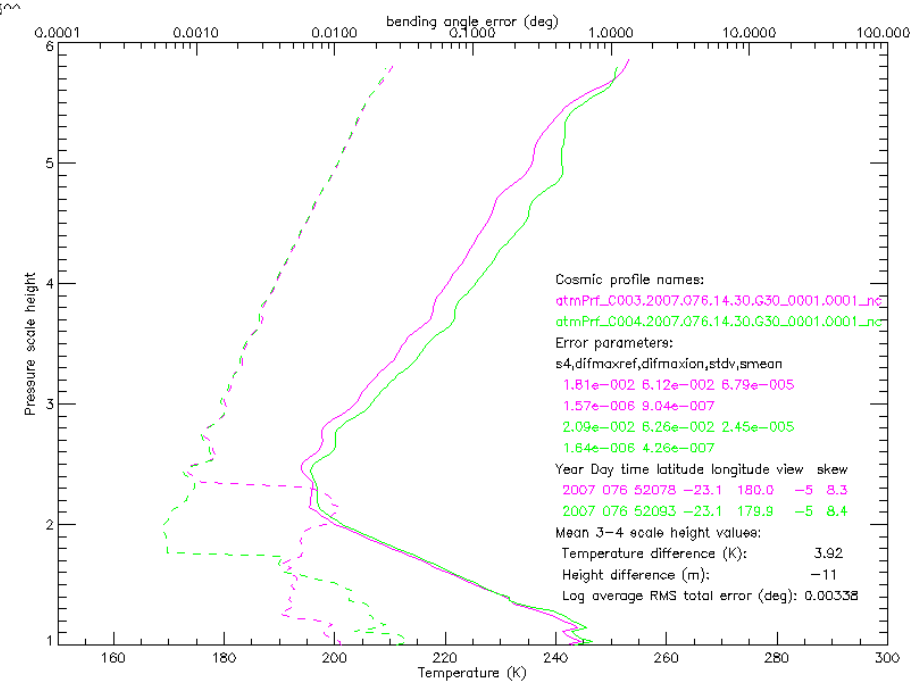

A small number of COSMIC profiles deviated from HIRDLS in the mean much more than was expected from other validation, and for no apparent reason.

This prompted a comparison between near-coincident pairs of COSMIC profiles for which a tight criterion (0.75º great circle, 300 secs) gave many pairs.

*Above – example of excellent agreement between two COSMIC profiles.*

*Right – example of two nearly coincident COSMIC profiles diverging, but note how they have similar small scale structure.*

General impression gained is that COSMIC profiles show repeatable smaller scales, but more caution is needed for the absolute values above the lower stratosphere.

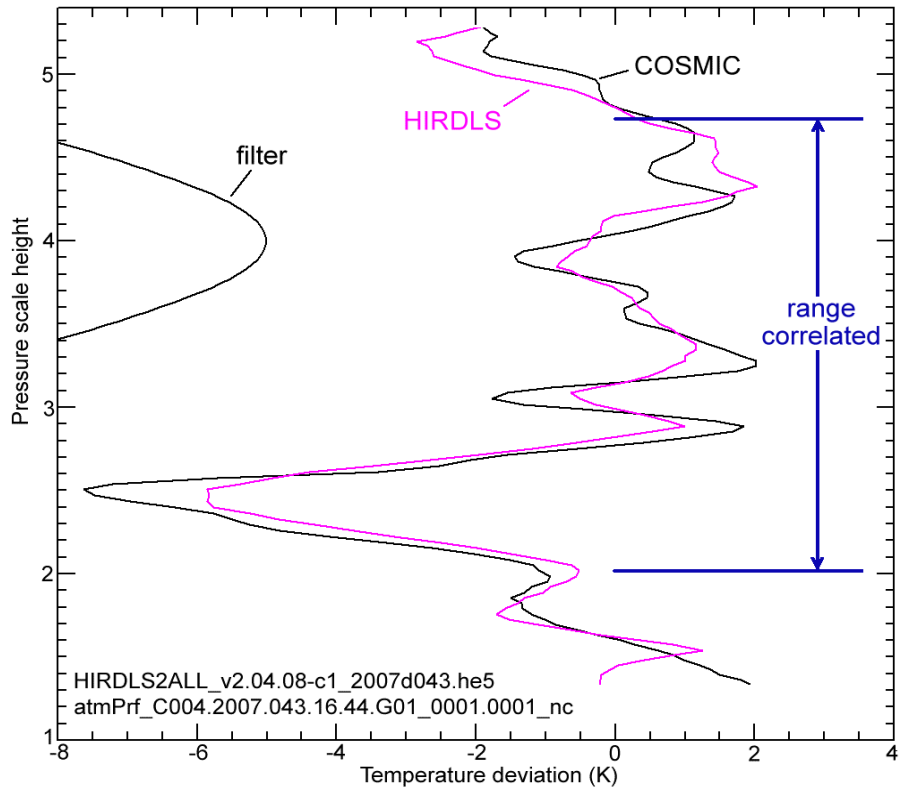


# Intercomparison of the small vertical distance scales of HIRDLS and COSMIC

To intercompare pairs of HIRDLS and COSMIC profiles they were separately smoothed using a cosine bell filter of 5.6 or 2.8 km full width at half height. The deviations from these profiles (which had therefore been high pass filtered) were then intercorrelated over the range 2.0 to 4.75 pressure scale height.

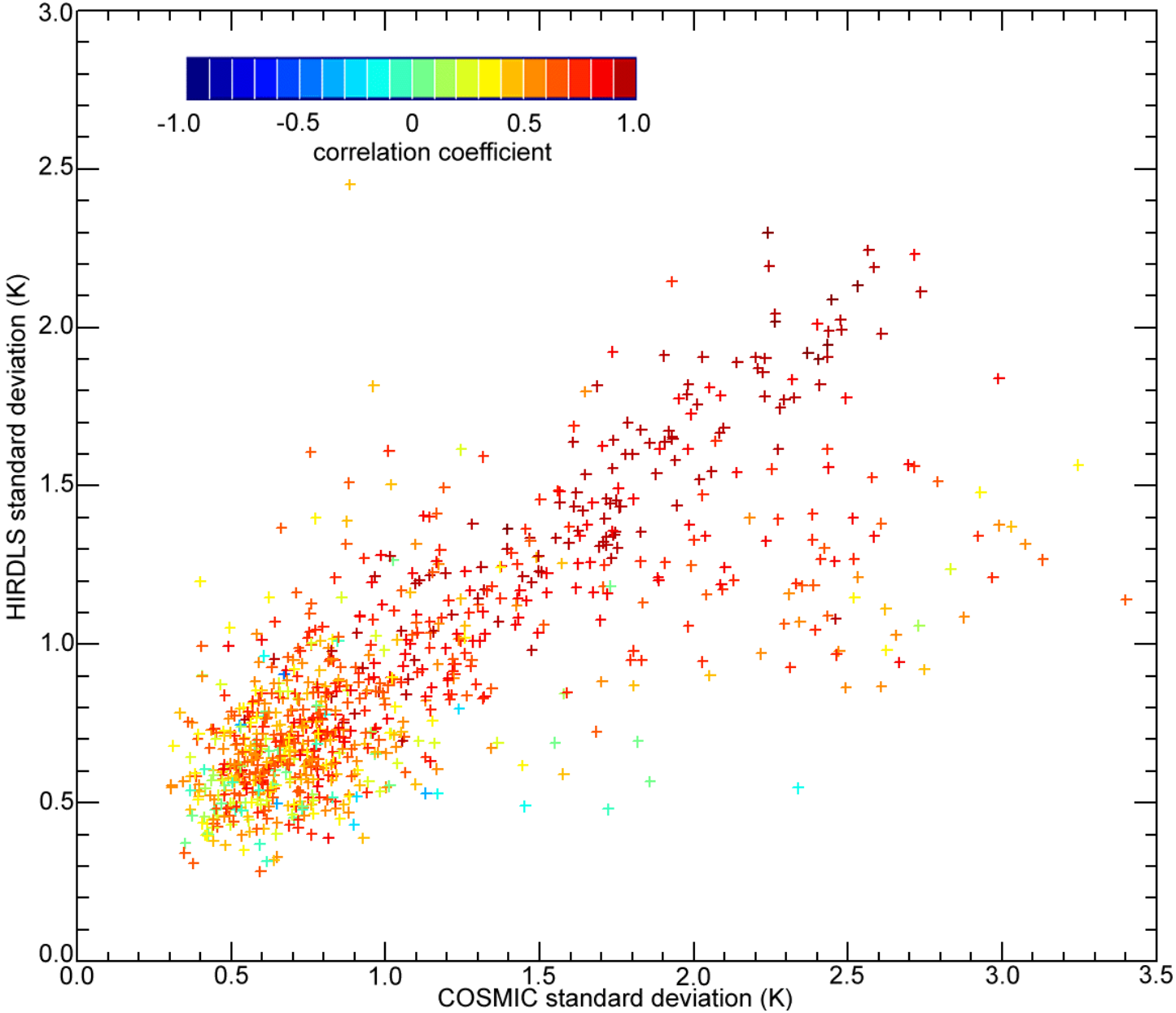
Profiles  required to be within 0.75º great circle and 500 sec of each other, giving 888 pairs.

All profile pairs with sufficient height overlap were used ( although elimination of profiles with large bending angle errors would have given a small improvement in correlation).



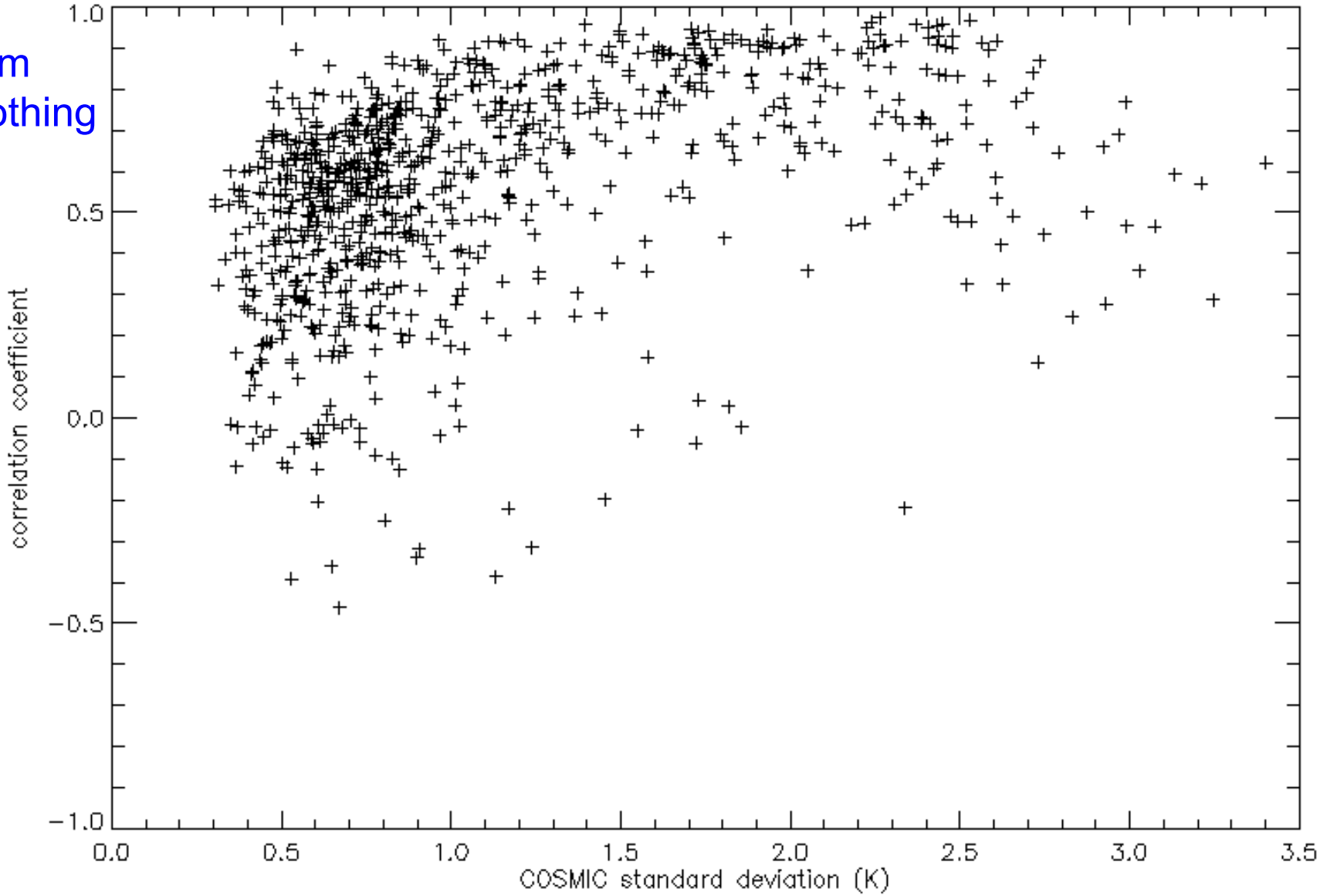

*Filter used and specimen pair of deviation profiles using the 5.6 km wide smoothing filter*

5.6 km smoothing filter

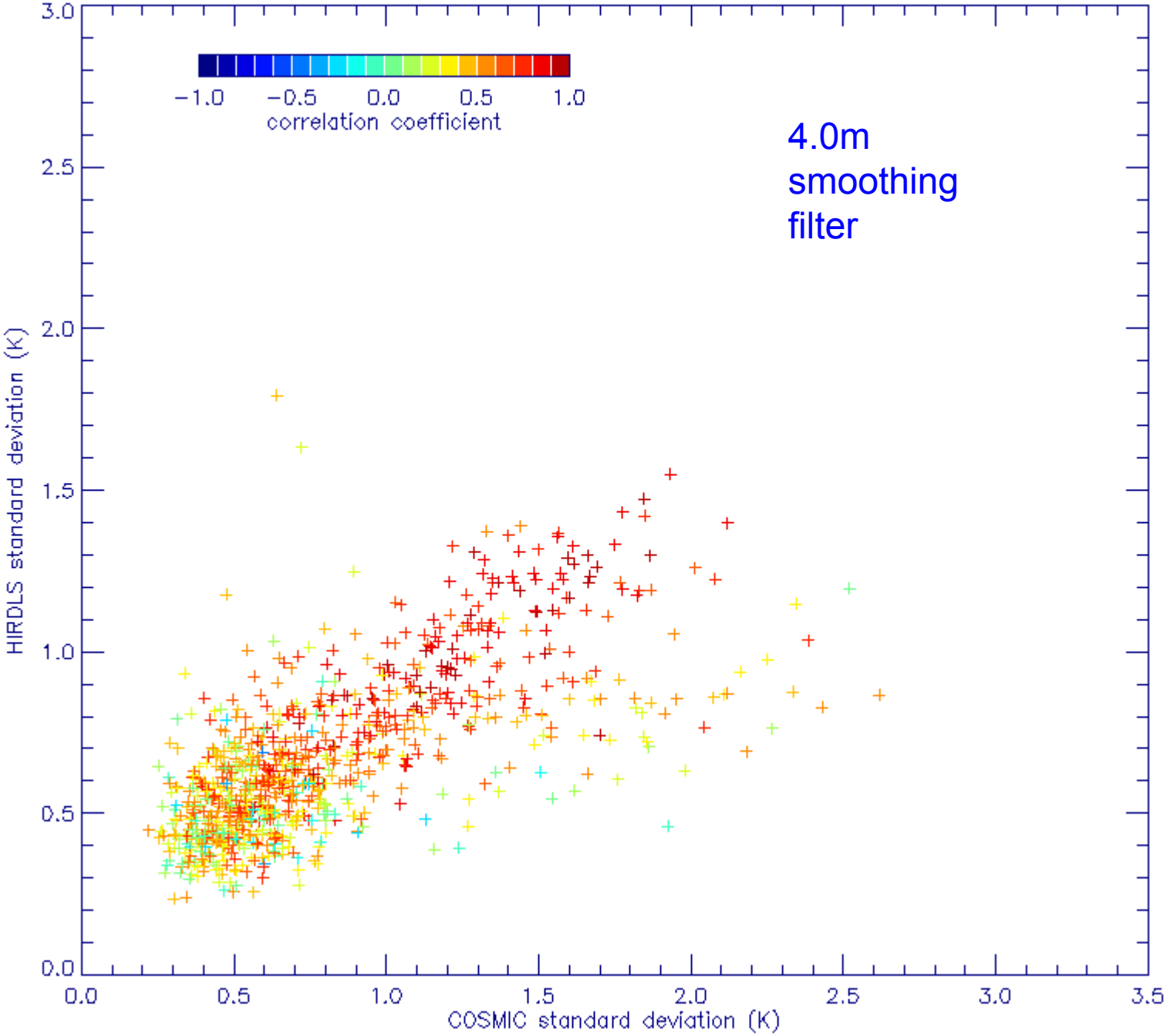


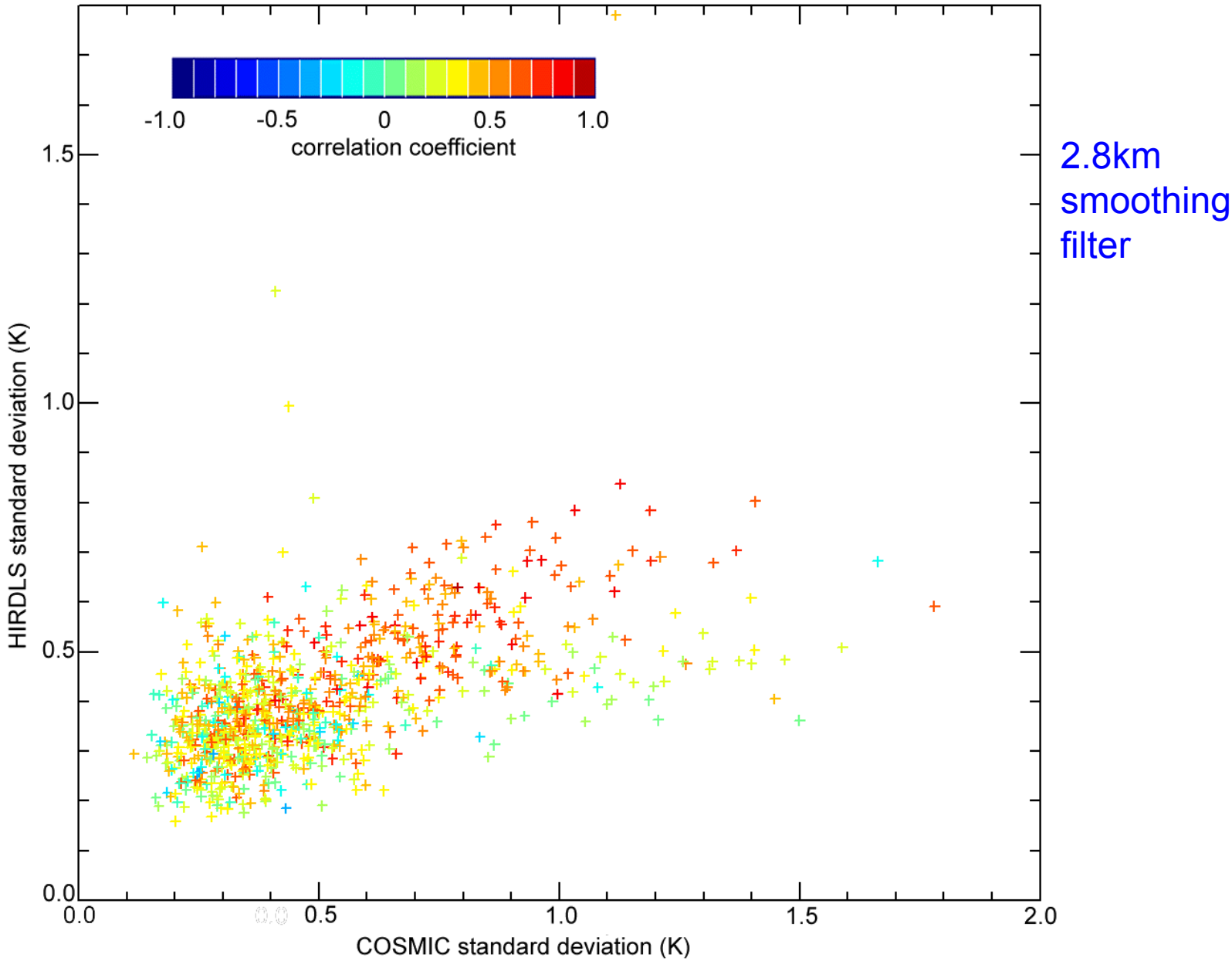

HIRDLS vs. COSMIC standard deviation of temperature from smooth profiles over 2.0-4.75 pressure scale heights for near coincident profiles. Crosses are colour coded with the correlation coefficient over this range. Note that most profiles are positively correlated.

5.6 km smoothing filter

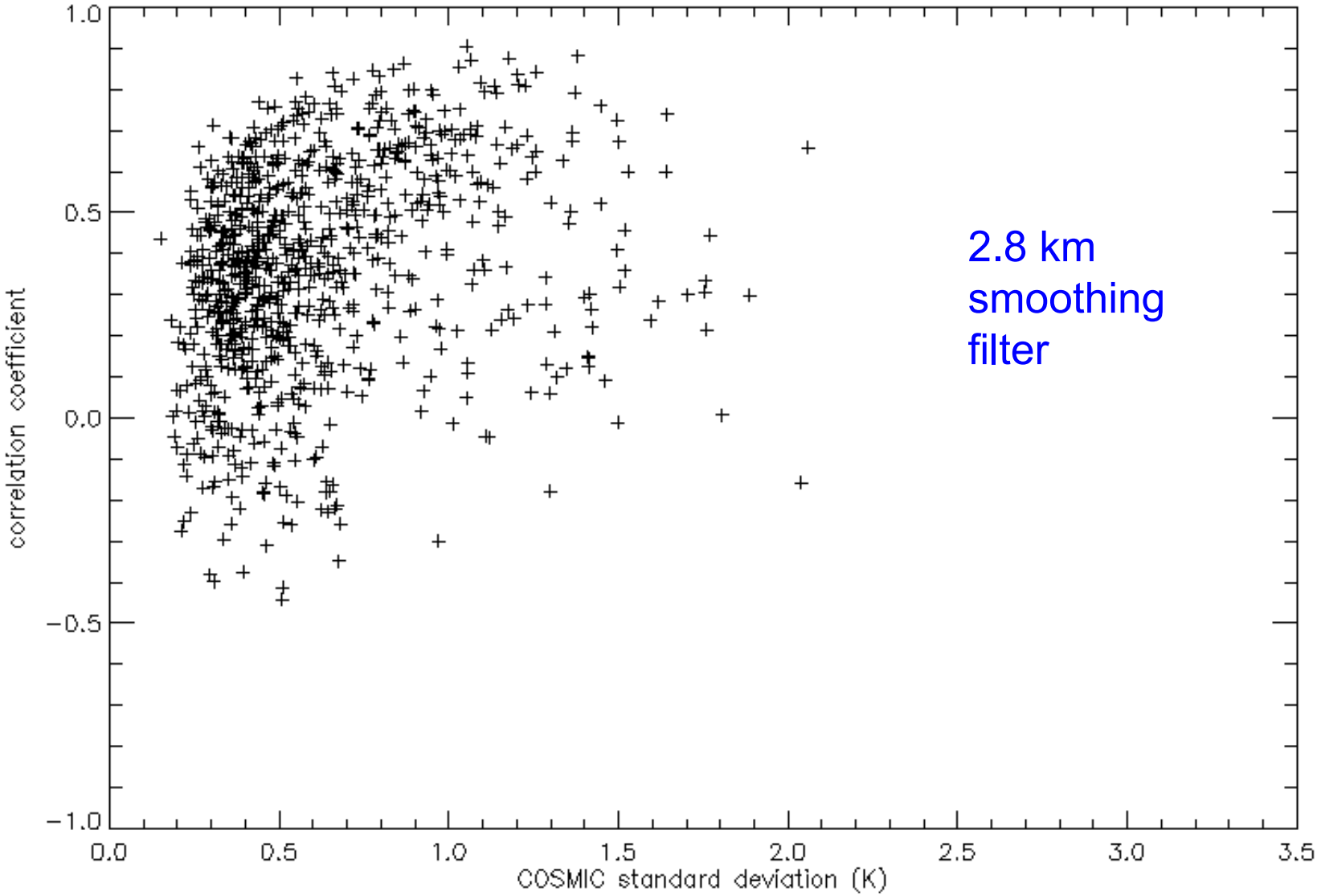



Correlation coefficient between HIRDLS and COSMIC perturbations over 2.0-4.75 pressure scale heights vs standard deviation of COSMIC profile over this range. Correlation coefficients are nearly all positive with small values tending to be when the standard deviation is small.


−1.0
−0.5
0.0
0.5
1.0
correlation coefficient
4.0m
smoothing
filter
HIRDLS standard deviation (K)
COSMIC standard deviation (K)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5




As before but for the 2.8 km wide smoothing filter; not the reduced amplitude of the deviations but large HIRDLS still correspond to large COSMIC and with correlations approaching 1.




HIRDLS/COSMIC correlation coefficients vs COSMIC standard deviation from the smoothed profile for a 2.8 km full width at half height smoothing filter.

# Comparison between *double* COSMIC and HIRDLS temperature profiles

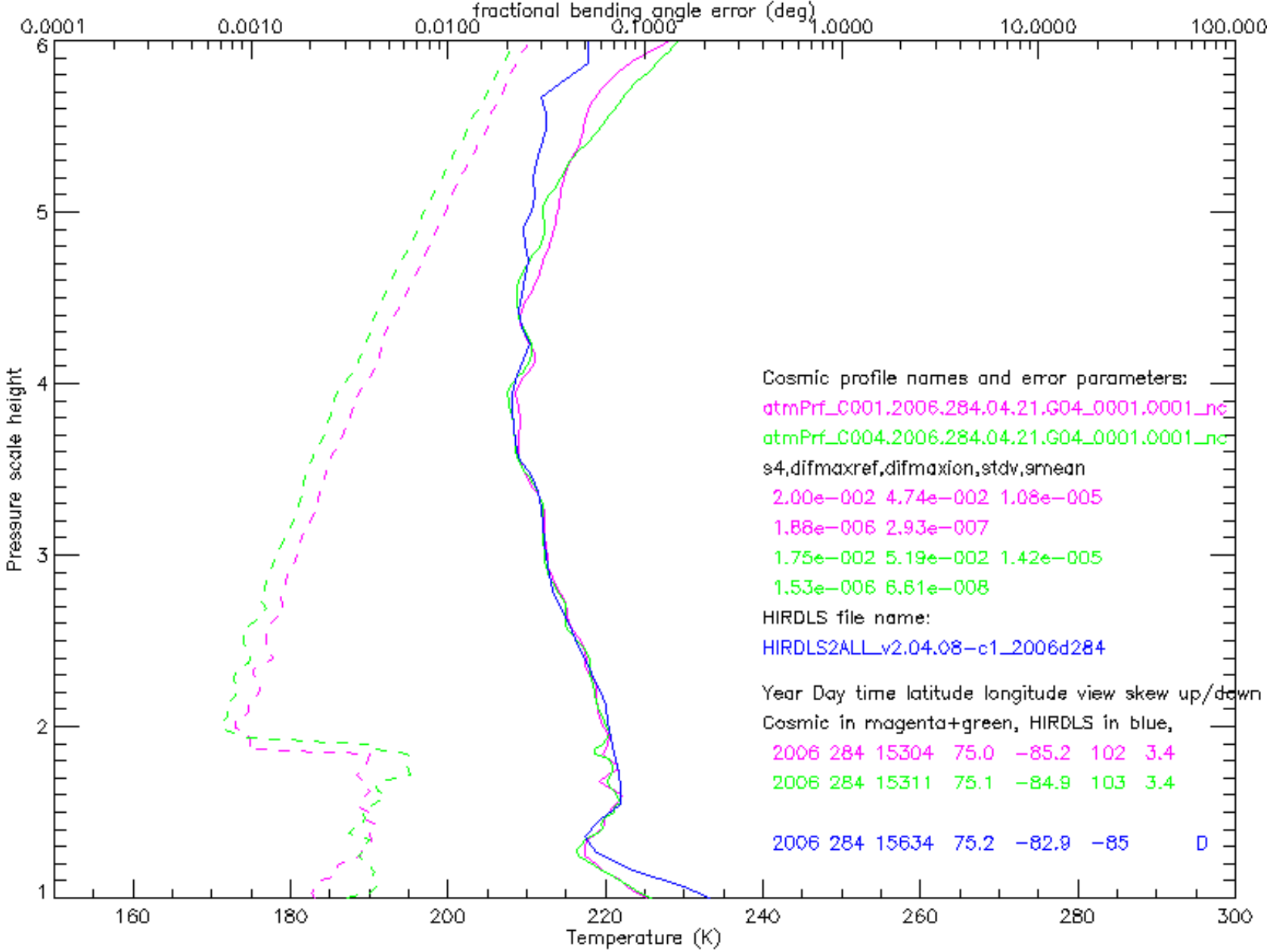
There are sufficient cases where two COSMIC profiles are close to each other to provide a cross check, and at the same time close to a HIRDLS profile to provide a useful cross-comparison of the mean HIRDLS-COSMIC temperature difference.

The pair of COSMIC profiles were required to be within 1.25º great circle distance and 1000 seconds of time of each other.

Any HIRDLS profiles were then required to be within 1.0º great circle distance and 800 seconds of time of the mean of the two COSMIC profiles.

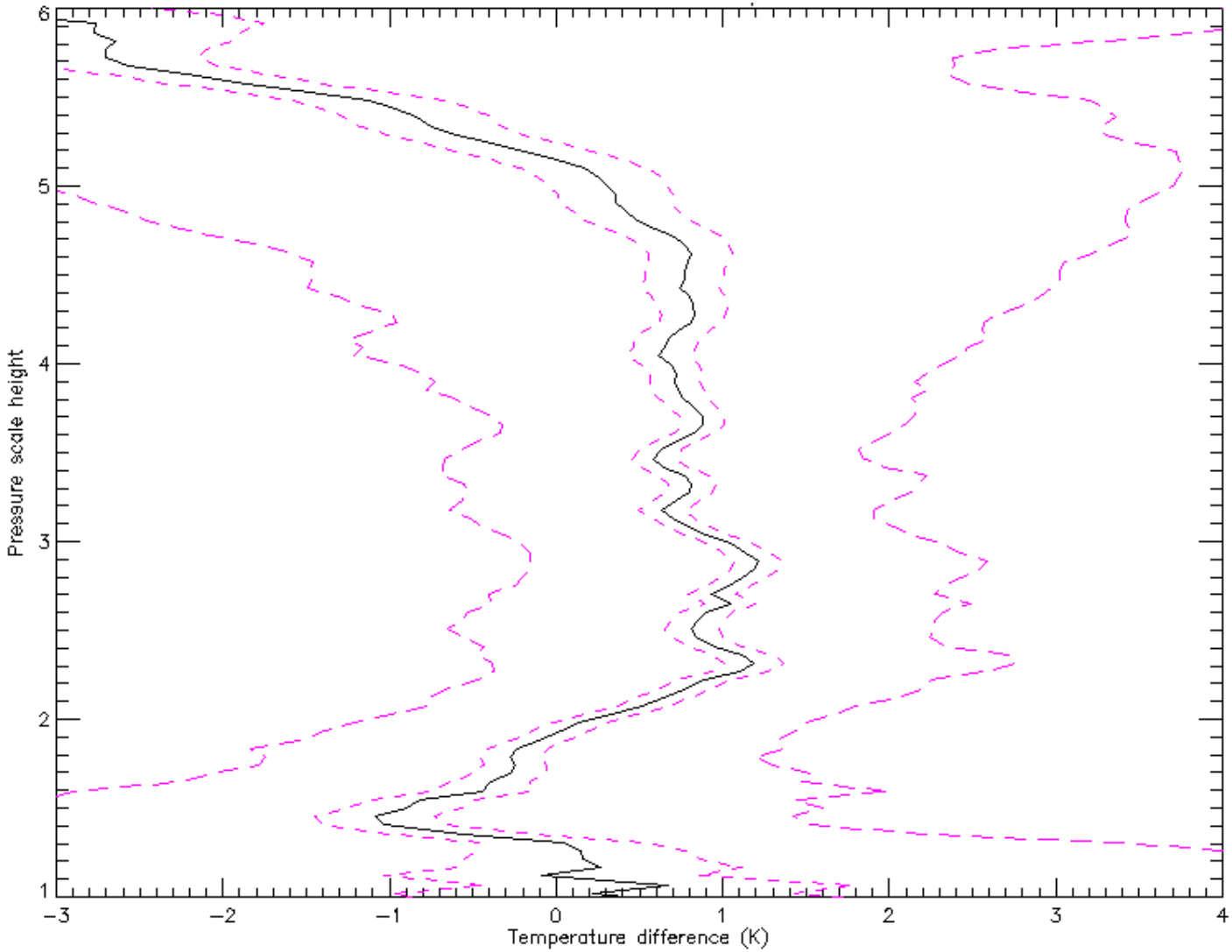
91 double COSMIC cases were found for the period 192 2006-239 2007. None of these was rejected for any reason.

Only a single HIRDLS profile was used in most cases because the window was too narrow to find more than one given the restriction to downward profiles. Where more than one was used they were averaged.

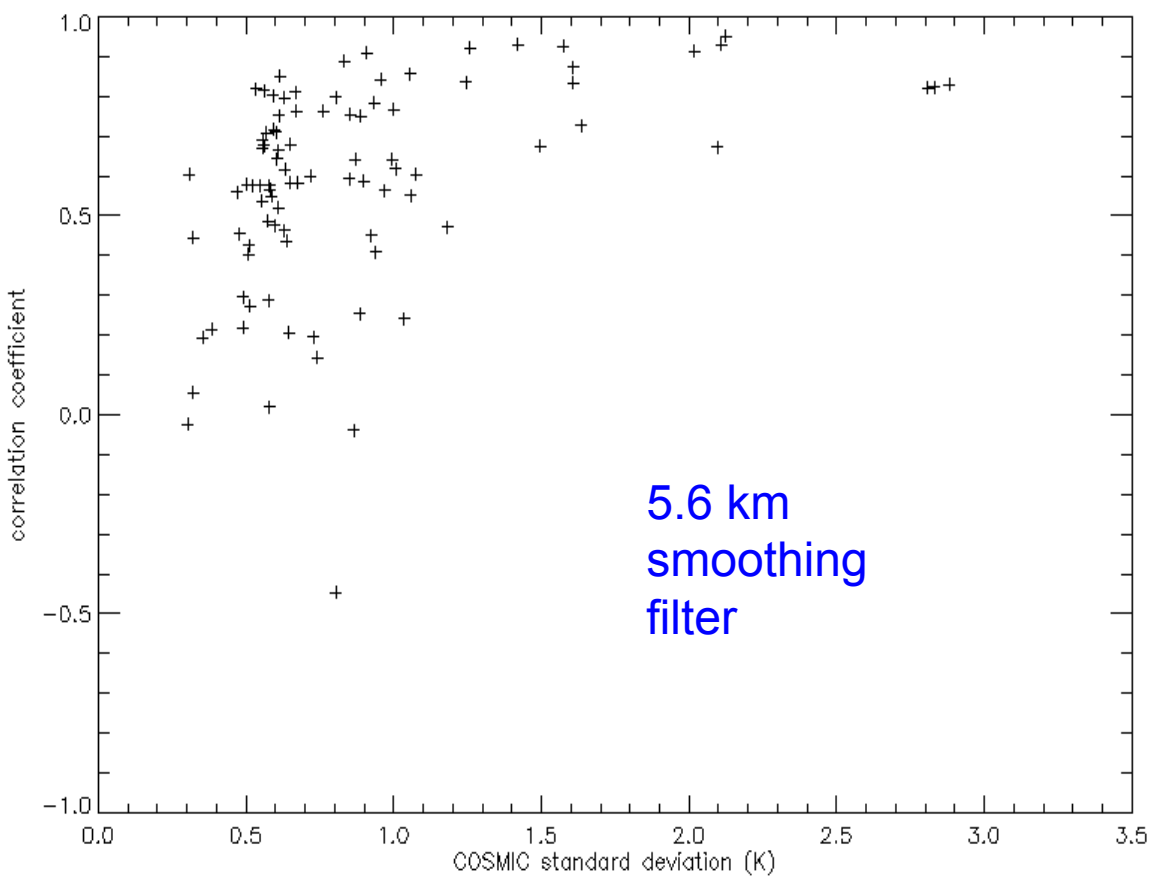


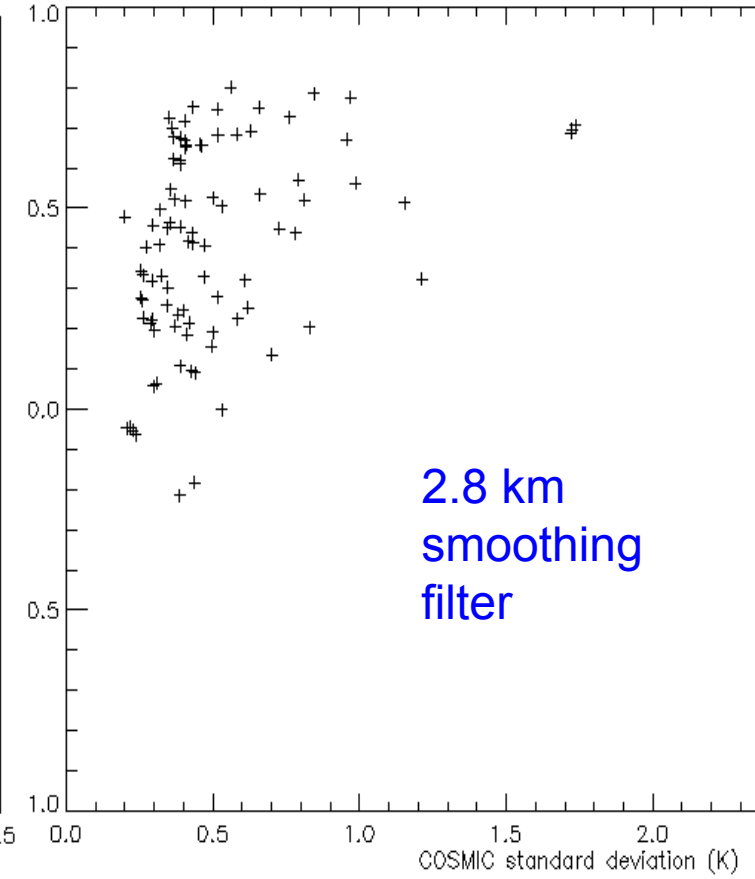

Example of two COSMIC profiles (at 75.0 N, 85.2 W and 75.1 N 84.9 W at 15304 and 15311 secs on day 284 2006) nearly coinciding with a HIRDLS profile (at 75.2 N, 82.9 E at 15634 secs).

# Mean Differences




Mean difference, HIRDLS-COSMIC, for the Double COSMIC+HIRDLS coincidences. The solid line gives the difference, the outer dashed lines give the difference +/- the standard deviation of comparisons about the mean, and the inner dashed lines give the 1 standard deviation error bars of the mean.




**Fine scale structure - as previously but for the double COSMIC + HIRDLS dataset.**

i.e. Correlation coefficient versus COSMIC standard deviations for the fine structure of the double COSMIC + HIRDLS data over 2.0-4.75 pressure scale heights.

For each comparison the mean of the pair of COSMIC profiles was correlated against the HIRDLS profile.

# Conclusions

Very tight intercomparison windows are possible between COSMIC and HIRDLS profiles. This provides an opportunity to intercompare the smaller vertical scales that also tend to have short time scales of minutes.

Good correlations are found for the three high pass filters widths used but with a slight tendency for the HIRDLS to see a smaller amplitude than COSMIC for the shortest case implying that COSMIC has a better vertical resolution as expected.

**HIRDLS vertical resolution is consistent with 1.2 km as originally planned.**

Mean temperatures are in good agreement, after applying quality control (although this was not one of the aims of the comparison).